UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
Resource Assessment and Conservation
Engineering Division
7600 Sand Point Way Northeast
BIN C15700, Building 4
Seattle, Washington 98115-007

March 12, 1990 F/AKC1:CR

CRUISE RESULTS
CRUISE PAT SAN MARIE-892
November 30-December 9, 1989

From November 30 to December 9, 1989, scientists from the Resource Assessment and Conservation Engineering (RACE) Division of the Alaska Fisheries Science Center, National Marine Fisheries Service, conducted experiments on trawl dynamics and their effects on catchability aboard the chartered fishing vessel Pat San Marie. These experiments were done in the Straits of Georgia, Washington, to determine the effects of variability in trawl shape on the results of bottom trawl surveys which are used to assess the status of groundfish stocks.

SCHEDULE

November 30	-	Loaded vessel and departed Sand Point Dock, Seattle. Restrictor and hydrophone tests, off Seattle
December 1	-	Arrived at Point Roberts site Deployed current meter Commenced comparative towing
December 3-5	-	Off charter for vessel repairs
December 6-8	-	Continued comparative towing
December 9	-	Recovered current meter Returned to Sand Point Dock, Seattle

OBJECTIVES

Objectives of the study were to:

1. Test for changes in catchability associated with trawl width variation.

2. Develop a system of restrictors which will reduce or eliminate variation in trawl width due to changing fishing conditions.

3. Observe the effects of bottom currents and towing speed on trawl dimensions.

4. Measure differences in net mensuration signal reception from various deployments of the system's hydrophones.

METHODS

Vessel and Gear

The study was carried out aboard the chartered fishing vessel Pat San Marie, a 30.8 m (101 ft) stern trawler. Both standard RACE survey trawls were used in the study. Most of the work was done with the 83/112 Eastern trawl, a low opening trawl rigged to minimize escapement under its cable footrope. One day was spent studying the performance and catchability of the poly Nor'Eastern trawl, a high opening trawl equipped with roller gear and a reduced lower wing to allow fishing over rough substrates. Both trawls were fished with 2 X 3 m (6 X 9 ft) steel V-doors weighing approximately 817 kg (1,800 lb) attached to the net by 55 m (30 fm) dandylines.

Trawl Mensuration

The operating dimensions of the trawls were monitored throughout the study with an acoustic net mensuration system. Horizontal dimensions were measured by sensors on the starboard side of the gear by measuring the time required for an acoustic pulse to travel to a transponder on the port side and back. Measurements were made of the distance between the trawl doors and across the mouth of the net. The distance above the bottom of both the trawl headrope and the restrictors were measured with sensors which timed the reflection of an acoustic pulse off of the sea floor.

Restrictor Testing

A valuable characteristic for a groundfish survey trawl is for it to sample in a consistent fashion under all conditions. Therefore, the technique of attaching a line between the port and starboard towing cables at or ahead of the trawl doors was tested as a means of reducing trawl width variation. This control over trawl shape was also necessary for accomplishing the catchability experiment.

A series of tows of the 83/112 Eastern trawl equipped with different restrictor arrangements was done on the first day to determine the most effective length and placement for controlling trawl width. These tows were done in central Puget Sound at a depth of 185 m. Two restrictor lengths were used, 20 m and 15 m; both attached to the towing cables 46 m (25 fathoms) in front of the trawl doors. A control tow was done with no restrictor. Seven lengths of towing cables (scopes) were used during each tow (91, 137, 229, 366, 457, 549, and 640 m). Trawl width was measured while towing for five minutes at each length.

The effects of restrictors on variability in trawl width was also monitored during the catchability experiment. This included tows with 10 and 30 m restrictors attached 46 m in front of the doors and tows with 45 and 60 m restrictors attached at the doors.

<u>Catchability</u>

Acoustic observations of trawl operating dimensions during resource assessment surveys have shown that trawl widths vary significantly between tows. This has been shown to directly affect survey results through the use of trawl width data to determine the area swept by each trawl tow. It was unknown whether results are also affected by changes in the efficiency with which the survey trawls catch fish (catchability) due to changes in trawl shape. This study tested for such an effect by comparing the catches of paired trawl tows where a trawl was fished at different widths.

To test for changes in catching efficiency with different trawl widths, the trawls were fished with restrictors set to achieve widths of 12 and 15 m. Initially, this was done with 10 and 30 m restrictors attached 46 m ahead of the trawl doors. When this proved to allow too much width variability between tows, they were replaced with 45 and 60 m restrictors attached at the doors.

All of these tows were done in a 1 X 2 nm area southwest of Point Roberts in the Straits of Georgia. Depths ranged from 110 to 128 m. Paired trawl tows were done on adjacent tracks less than .2 nm apart and starting approximately 1 hr apart. Tows were made for fifteen min at three knots speed through the water.

Initial analysis consisted of calculating the differences of the log transformed catches of the four most common species for each pair. Back transformation of the resulting statistics produced estimates and confidence intervals for the ratios of catchability between wide and narrow configurations. Simple ratio of means estimates were also calculated.

Effects of Currents

Among the factors which can influence the working shape of an otter trawl, bottom currents have been one of the more difficult to measure during towing operations. For this study, a current meter was moored close to the study area to record currents on the sea floor. This allowed direct comparison of trawl dynamics with those currents.

Bottom current measurements were taken simultaneously with all of the work in the Point Roberts area. Bottom currents ranged from negligible up to 2 knots. One current effects tow was done with each net. This consisted of fishing with, against, and across the prevailing currents alternating towing speeds at 3 knots through the water and 3 knots measured relative to the sea floor. This pattern resulted in one set of three periods with varying speed through the water and standardized speed over the bottom and one set where speed over bottom varied and speed through the water was relatively constant.

Hydrophone Deployment

The most significant problem limiting the use of the net mensuration equipment used in this project is the ability to receive signals from the trawl sensors with a hydrophone deployed from the towing vessel. Reception of signals from the net mensuration gear was compared for four different deployments of the receiving hydrophone, including:

1. towing the hydrophone with two 10 pound weights, the present standard deployment;

2. attaching the hydrophone to the towing cable of a V-fin depressor with a metal plate which allowed the hydrophone's downward angle to be adjusted;

3. use of a hydrophone designed for hull mounting which was attached directly to the V-fin depressor; and

4. attaching the hydrophone to the center of a line slung athwartships under the bow to place it at the keel.

Both the weighted hydrophone and the V-fin were towed from 4 m outriggers located about 7 m aft of the bow. Reception was monitored for all deployments during all phases of the cruise.

RESULTS

Restrictor Testing

Both the 20 and 15 m restrictors set 46 m ahead of doors nearly eliminated width variation while the trawl was off of the bottom (Figure 1). While the trawl was on the bottom (Scope > 175 fathoms), the increase in spread was reduced, but not eliminated. The spread of the unrestricted trawl increased 6 m when the scope went from 366 to 549 m (200-300 fathoms) but increased only 5 m with the longer restrictor and 2.5 m with the shorter.

Use of the 15 m restrictor resulted in a 13 m trawl width at the normal scope (549 m) for this depth. Since this was wider than preferred for the narrow configuration in the catchability experiment, a 10 m restrictor was selected to achieve the desired 12 m width. A 30 m restrictor was selected for the wide configuration. Both were still attached 46 m ahead of the doors.

During the catchability experiment, use of the 10 m restrictor continued to yield trawl widths of 13 m. Even though all tows were made with the same scope, 366 m (200 fathoms), widths were still found to vary considerably both within and between tows using both 10 and 30 m restrictors (Figure 2). Widths ranged from 11.5 to 14.5 m in the narrow configuration and from 13.5 to 16.5 in the wide configuration. In some cases, trawl widths were equal for paired tows with both long and short restrictors. After observing trawl performance for two days, 45 m and 60 m restrictors placed **at the doors** were selected to improve control. These lengths corresponded to the average door spreads during the earlier tows. The subsequent tows showed that the short (45 m) restrictor maintained an opening that varied only a few tenths of a meter both within and between tows and variability with the long restrictor was limited to a range of 14.3 to 15.6 m.

Catchability

Sixteen pairs of tows completed with the 83/112 Eastern trawl rigged to fish at different widths. Of these, five could not be used for the width comparison. On four occasions, widths did not differ enough and in one instance catches of all species were so small that a malfunction is suspected. Of the remaining 11 pairs, width differed by about 2 m, averaging about 13 m for the narrow configuration and 15 m for the wide.

No significant differences in catchability by width were detected, with all ratios within 30% of unity (Table 1). The direction of the mean values indicated higher efficiency with narrower spreads for English sole (*Parophrys vetulus*) and rex sole (Glyptocephalus zachirus) and a decrease for spiny dogfish (Squalus acanthius). The direction of the walleye pollock (Theragara chalcogramma) estimate changed between the two estimation methods.

Table 1.--Estimates of catchability ratios for wide and narrow configurations of two survey trawls.

Trawl	Species	Estimates of Ratio: Mean Log Difference	Estimates of Ratio: Ratio of Means	95% Confidence Interval
83/112	English Sole	1.17	1.26	0.62 - 2.24
	Walleye Pollock	0.95	1.12	0.17 - 5.21
	Rex Sole	1.10	1.20	0.39 - 3.13
	Spiny Dogfish	0.70	0.71	0.10 - 4.67
Poly NE	English Sole	0.87	0.86	0.62 - 1.24
	Walleye Pollock	0.94	0.90	0.42 - 2.13
	Rex Sole	0.88	0.89	0.19 - 4.11
	Spiny Dogfish	1.83	1.87	0.69 - 4.89

Data on the length composition of each major species were also taken. A comparison of these lengths between the wide and narrow configurations showed no clear trends in selectivity by length (Figure 3). More flatfish less than 15 cm were taken with the wide configuration, but this is based on a very small sample.

Though only three pairs of comparison tows were usable for the Poly Nor'Eastern net, the confidence ranges for the catchability differences were not much larger than for the 83/112 Eastern experiment. The directions of the indicated differences were opposite, however, with the narrow configuration slightly less efficient than the wide for the flatfish and pollock and more efficient for dogfish. Again, the differences were not statistically significant.

The sensitivity of the tests of significance were affected by the relatively small sample sizes. With a sample size of only 11 pairs, only a doubling or halving of the catch rate would have been statistically significant for English sole, the least variable species. Sample sizes greater than 35 pairs would be necessary to detect a difference as small as 20%, the mean for this species.

Two other catchability comparisons were made with this data, though they could not take advantage of the original pairing of tows. Because of this, the results of both of these non-paired comparisons could be confounded by changes in fish abundance at the site during the study. This and the high variability of catch rates require caution in interpreting any differences.

The first two days of comparison towing with the 83/112 Eastern trawl were done with the restrictor attached 46 m (25 fathoms) ahead of the doors, which puts it about 17 m above bottom. During the second two days of towing, it was attached at the doors, where it cleared the bottom by just over a meter. The effects of having this restrictor near the bottom in the path of the net could have been reflected in differences between catches (Table 2). With the low restrictor, the total flatfish catch rate decreased slightly, with a decrease in the catch of English sole partially offset by an increase in flathead sole catch. Pollock catch rates nearly doubled, causing the total gadid catch to increase and the dogfish catch declined from 26.5 to 16.0 kg/hectare.

Catch rates with the Nor'Eastern trawl on the last day were compared with the 83/112 Eastern trawl catches from the previous two days to test for differences between the trawls. Catch rates approximately doubled for flatfish taken with the Nor'Eastern trawl, with the largest increase for flathead sole and moderate increases for all of the other species. This increase is surprising, since flatfish escapement through the roller gear would be expected to be greater than under the footrope of the 83/112 Eastern. Both gadid and dogfish catch rates also nearly doubled, while the ratfish catch decreased dramatically.

Effects of Currents

The width of the 83/112 Eastern trawl decreased slightly with increases in both speed over the bottom and speed through the water (Figure 4). Width of the Poly Nor'Eastern decreased with higher speeds through the water and increased with greater speeds over the bottom. The usual inverse relationship between trawl height and width occurred in all cases except for the 83/112 Eastern with changing speed over the bottom.

Neither speed over the bottom, speed through the water, nor cross currents had any noticeable effect on width of the 83/112 trawl during the catchability tows. This is not inconsistent with the slight difference indicated by the current effects tows.

Table 2.--Catch rates (kg/hectare) for 83/112 trawl with restrictors at different heights and for poly Nor'Eastern trawl.

Species	83/112 Eastern Restrictor Height 17 m	83/112 Eastern Restrictor Height 1 m	83/112 Eastern Average	Nor'Eastern 1 m
English Sole	6.3	3.8	5.0	8.4
Rex Sole	1.4	1.3	1.3	2.2
Arrowtooth Flounder	1.0	1.1	1.0	2.0
Flathead Sole	0.2	1.3	0.8	6.8
Slender Sole	0.3	0.5	0.4	0.3
Total Flatfish	**9.6**	**8.4**	**9.0**	**20.1**
Walleye Pollock	2.2	4.3	3.2	4.9
Pacific Hake	1.6	1.6	1.6	7.9
Pacific Cod	1.0	1.4	1.2	1.2
Pacific Tomcod	0.5	0.7	0.6	1.1
Total Gadids	**5.2**	**8.0**	**6.6**	**15.1**
Spiny dogfish	26.5	16.0	21.3	40.7
Spotted Ratfish	4.3	5.3	4.8	0.9

Hydrophone Deployment

During the deepwater restrictor tests, the standard (10 kg weight) and keel mounted hydrophones received the most signals, while the one mounted on the V-fin received the fewest (Table 3). Fewer signals were received from the height sensor than the spread sensor. The keel mounted version only worked the first two days after which its support line failed.

Table 3.--Average signals received per 10 second period by haul number using four hydrophone deployments. (The maximum number of signals per 10 seconds is slightly over three.)

Deployment	Width Signals H1	Width Signals H2	Width Signals H4	Height Signals H1	Height Signals H2	Height Signals H4
With 10 kg weight	3.0	2.9	2.8	1.3	2.4	2.7
Keel Mounted	2.7	2.7	2.8	2.1	2.4	2.4
On V-Fin cable	2.6	2.5	2.8	1.9	1.9	3.3
On V-fin	2.1	2.1	1.9	1.2	1.7	1.5

While all hydrophones received a high proportion of the signals in the relatively shallow waters of the Point Roberts site, some of them were much worse on individual tows (Figure 5). The standard configuration had the largest number of these problem tows. Further study of these differences should indicate some reasons for reception problems during surveys and possibly some remedies. Since these tests were done in inside waters, the effects of oceans swells, which can certainly affect the performance of towed hydrophones, was not reflected.

SCIENTIFIC PERSONNEL

Craig Rose	AFSC	Chief Scientist
David Roetcisoender	AFSC	Biological Technician
Tom Wilderbuer	AFSC	Fishery Biologist
Terry Sample	AFSC	Fishery Biologist
Ken Weinberg	AFSC	Fishery Biologist

AFSC - Alaska Fisheries Science Center

For further information contact Dr. Gary Stauffer, Director, Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE., Building 4, BIN C15700, Seattle, WA 98115-0070 -- Telephone (206) 526-4170.

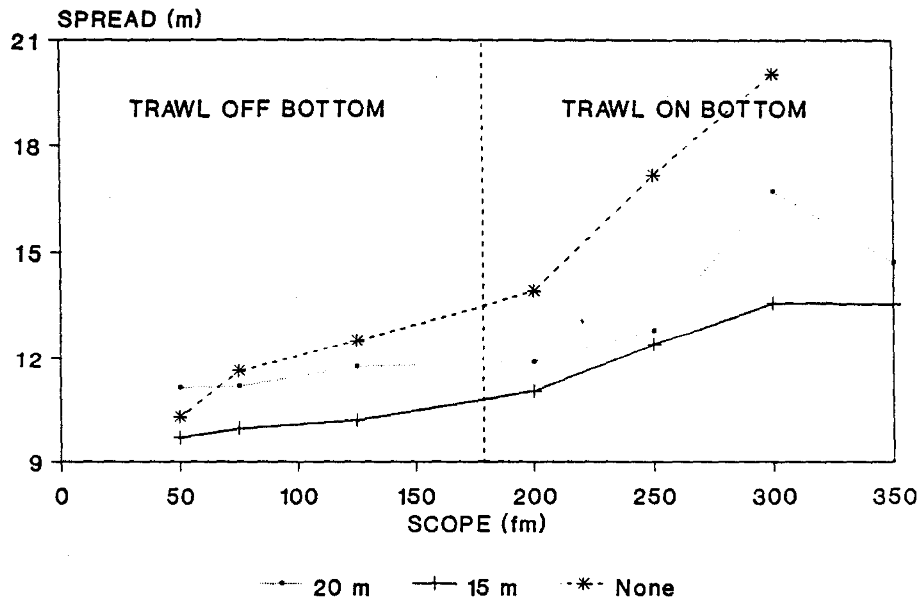


Figure 1.- Effects of restrictors on trawl width. Restrictors (20 & 15m) attached 46m (25fm) ahead of doors.

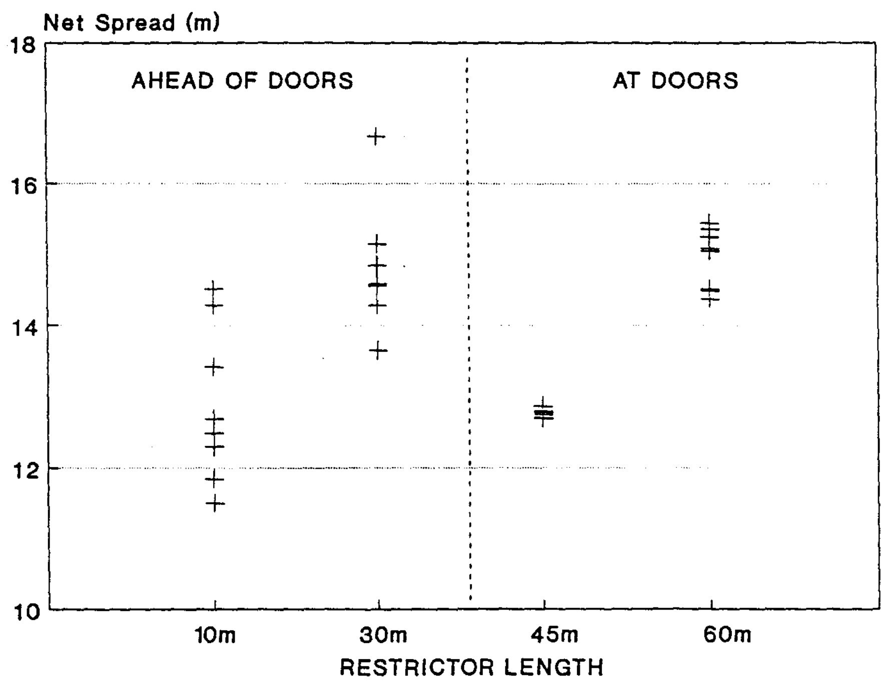


Figure 2.- Comparison of trawl width variablity with restrictors attached 46m (25fm) ahead of doors and at doors.

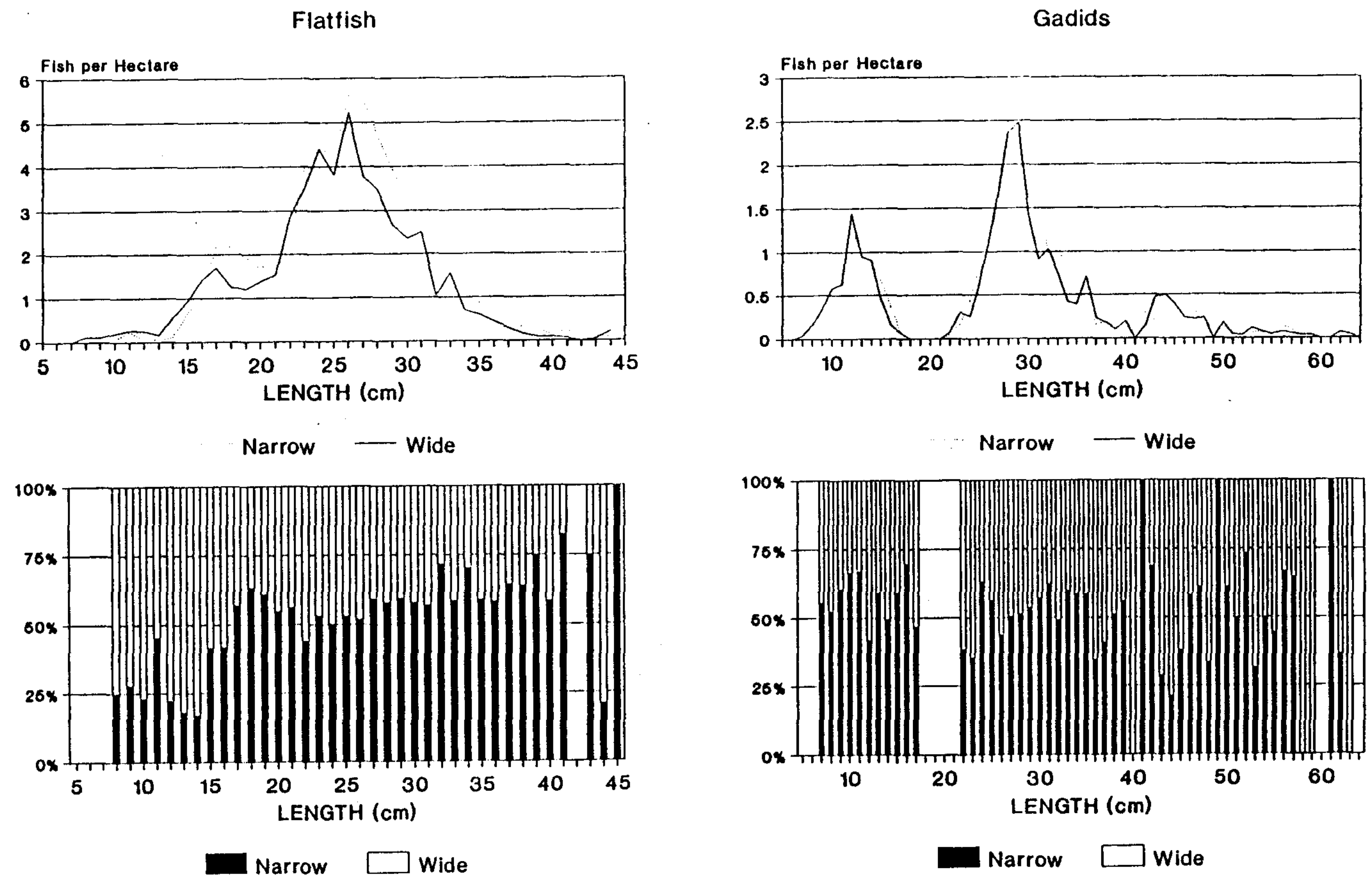


Figure 3. Length comparison of flatfish and gadids captured with wide and narrow configurations of 83/112 trawl.

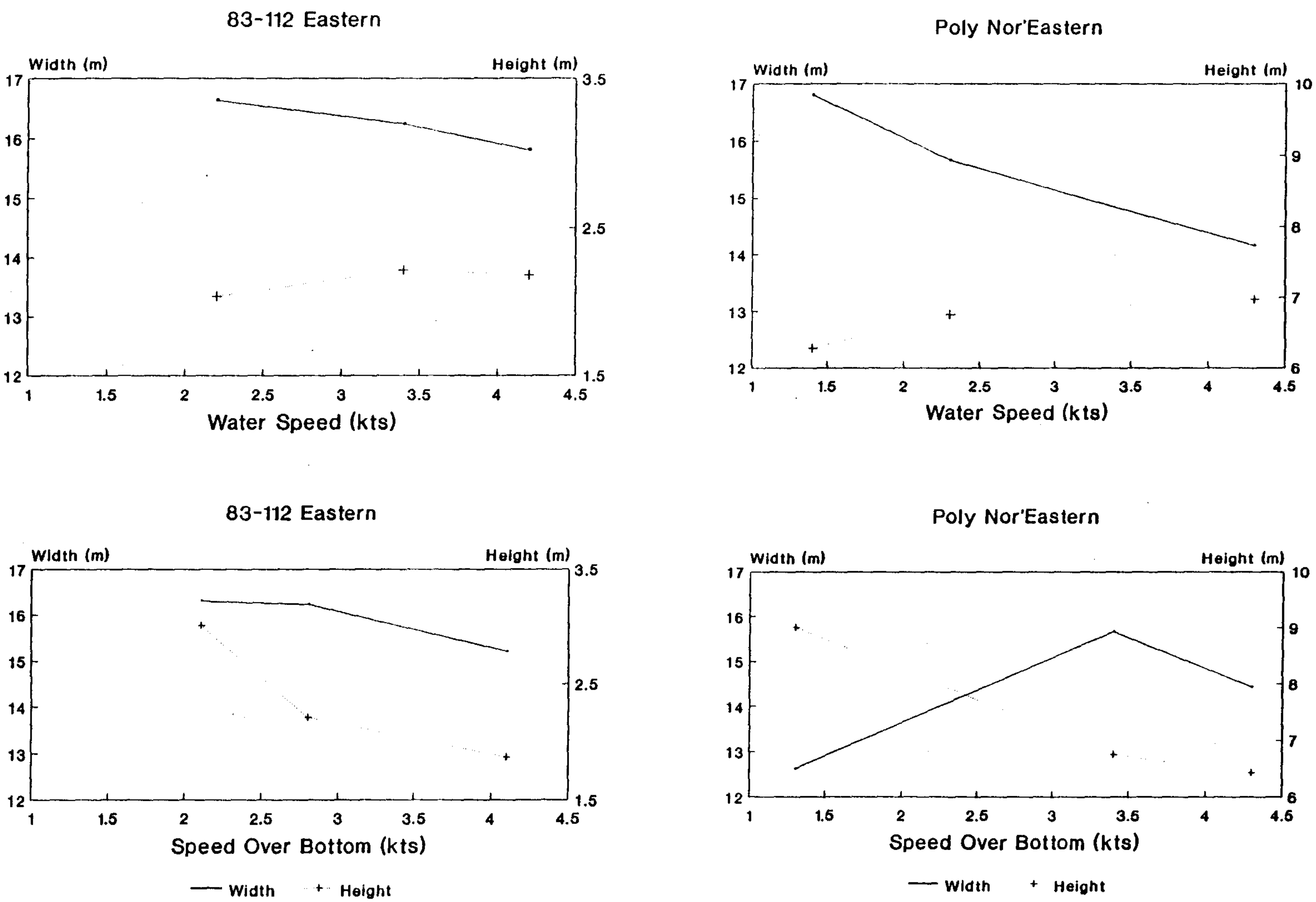
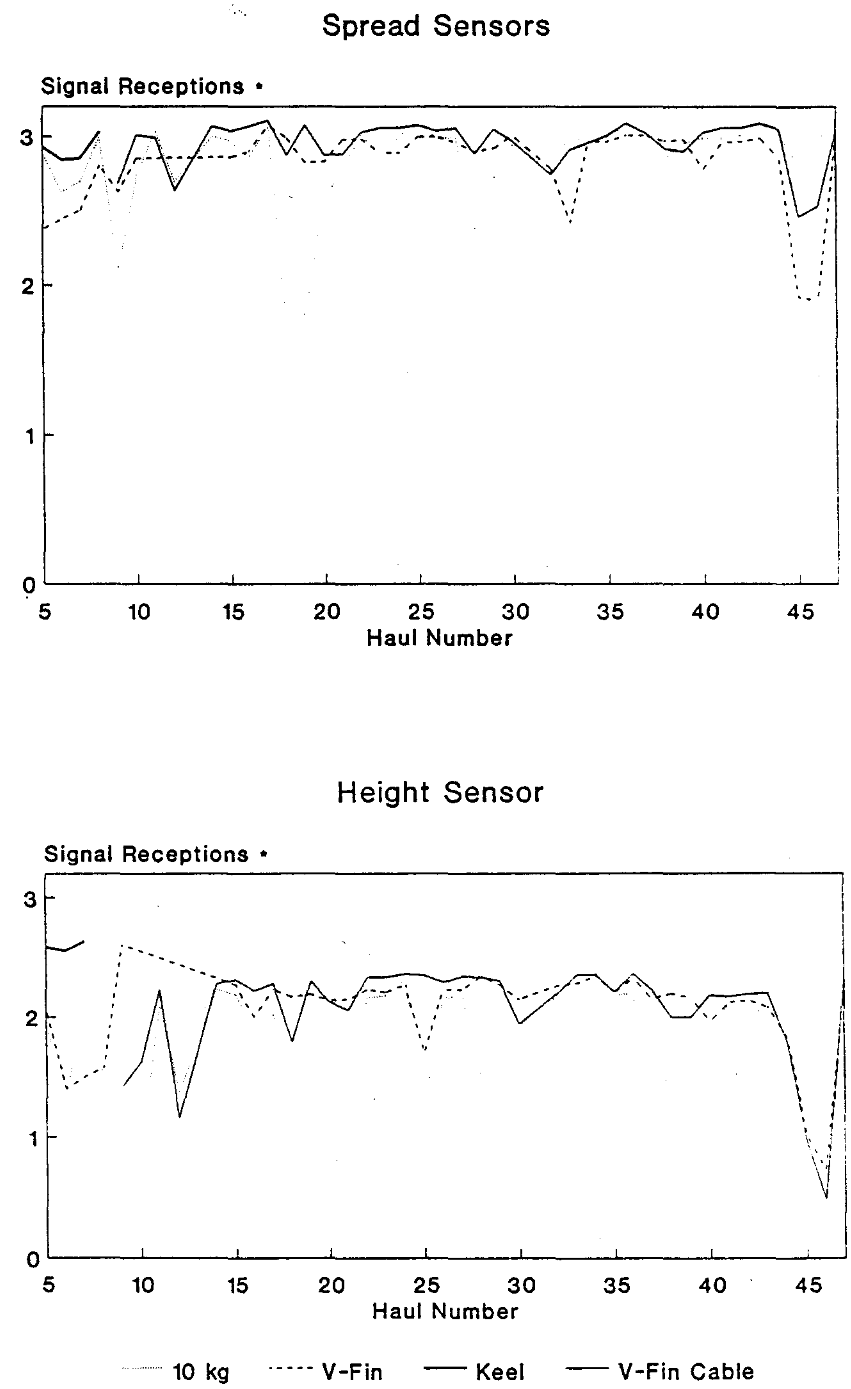


Figure 4.- Effects of changes in trawl speed through water and over bottom on trawl width and height.



* Mean signals recieved per 10 seconds.

Figure 5.- Frequency of signal reception by haul with different hydrophone deployments.